

SYSTEM SOFTWARE

When you purchase a personal computer, it usually has system software installed on its hard disk. **System software** consists of the programs that control or maintain the operations of the computer and its devices. System software serves as the interface between the user, the application software, and the computer's hardware.

Two types of system software are operating systems and utility programs. Several types of utility programs are included with an operating system. Other utility programs are available stand-alone, that is, as programs separate from the operating

system. This chapter discusses the operating system and its functions, as well as several types of utility programs for personal computers.

OPERATING SYSTEMS

An **operating system (OS)** is a set of programs containing instructions that work together to coordinate all the activities among computer hardware resources. Most operating systems perform similar functions that include starting a computer, providing a user interface, managing programs, managing memory, coordinating



FIGURE 8-1 Most operating systems perform similar functions, which are illustrated with Windows Vista in this figure.

tasks, configuring devices, establishing an Internet connection, monitoring performance, and providing file management utilities. Some operating systems also allow users to control a network and administer security (Figure 8-1).

In most cases, the operating system is installed and resides on the computer's hard disk. On handheld computers and many mobile devices such as smart phones, however, the operating system may reside on a ROM chip.

Different sizes of computers typically use different operating systems. For example, a mainframe computer does not use the same

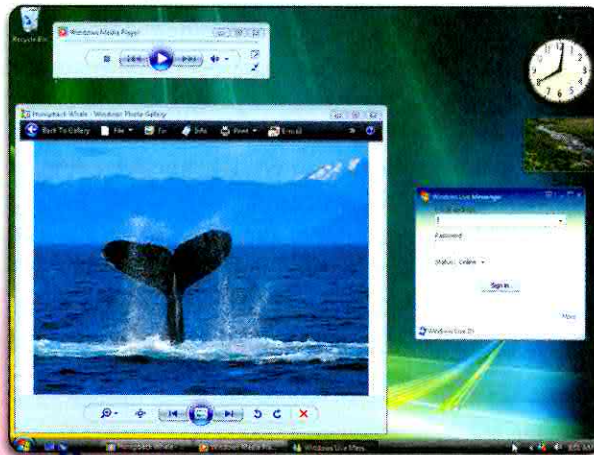
operating system as a personal computer. Even the same types of computers, such as desktop computers, may not use the same operating system. Some, however, can run multiple operating systems. When purchasing application software, you must ensure that it works with the operating system installed on your computer.

The operating system that a computer uses sometimes is called the *platform*. On purchased application software, the package identifies the required platform (operating system). A *cross-platform* program is one that runs the same on multiple operating systems.

provide a user interface



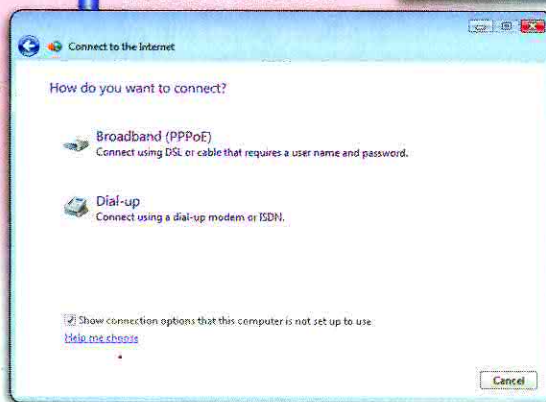
manage programs



manage memory



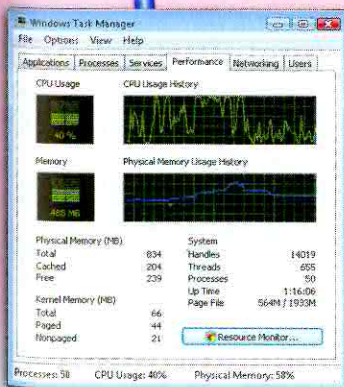
establish an Internet connection



coordinate tasks and configure devices



monitor performance



OPERATING SYSTEM FUNCTIONS

Many different operating systems exist, designed for all types of computers. Regardless of the size of the computer, however, most operating systems provide similar functions. The following sections discuss functions common to most operating systems. The operating system handles many of these functions automatically, without requiring any instructions from a user.

Starting a Computer

The process of starting or restarting a computer is called **booting**. When turning on a computer that has been powered off completely, you are performing a **cold boot**. A **warm boot**, by contrast, is the process of using the operating system to restart a computer. A warm boot properly closes any running processes and programs; however, it does not save any unsaved work. Thus, always remember to save your work before rebooting (restarting) a computer.

With Windows Vista, you can perform a warm boot by clicking the Start button on the taskbar, clicking the Lock button arrow on the Start menu, and then clicking Restart on the Lock button menu (Figure 8-2).

When you install new software or update existing software, often an on-screen prompt instructs you to restart the computer. In this case, a warm boot is appropriate. If the computer stops responding, try pressing the power button to turn off the computer. As a last resort, remove power from the computer and then restart the computer. On newer computers, pressing the power button momentarily is the same as a warm boot, whereas pressing and holding the power button does not properly close running processes and programs.

Each time you boot a computer, the kernel and other frequently used operating system instructions are loaded, or copied, from the hard disk (storage) into the computer's memory (RAM). The *kernel* is the core of an operating system that manages memory and devices,

maintains the computer's clock, starts programs, and assigns the computer's resources, such as devices, programs, data, and information. The kernel is *memory resident*, which means it remains in memory while the computer is running. Other parts of the operating system are *nonresident*, that is, these instructions remain on the hard disk until they are needed.

When you boot a computer, a series of messages may be displayed on the screen. The actual information displayed varies depending on the make and type of the computer and the equipment installed. The boot process, however, is similar for large and small computers.

The steps in the following paragraphs explain what occurs during a cold boot on a personal computer using the Windows Vista operating system. The steps in Figure 8-3 illustrate and correspond to the steps discussed in the following paragraphs.

Step 1: When you turn on the computer, the power supply sends an electrical signal to the components in the system unit.

Step 2: The charge of electricity causes the processor chip to reset itself and find the ROM chip(s) that contains the BIOS. The **BIOS** (pronounced BYE-ose), which stands for *basic input/output system*, is firmware that contains the computer's startup instructions.

Step 3: The BIOS executes a series of tests to make sure the computer hardware is connected properly and operating correctly. The tests, collectively called the *power-on self test (POST)*, check the various system components including the buses, system clock, adapter cards, RAM chips, mouse, keyboard, and drives. As the POST executes, LEDs (tiny lights) flicker on devices such as the disk drives and keyboard. Beeps also may sound, and messages may be displayed on the screen.

Step 4: The POST results are compared with data in a CMOS chip. As discussed in Chapter 4, CMOS is a technology that uses battery power to retain information when the computer is off. The CMOS chip stores configuration information about the computer, such as the amount of memory; type of disk drives, keyboard, and monitor; the current date and time; and other startup information. It also detects any new devices connected to the computer. If any problems are identified, the computer may beep, display error messages, or cease operating — depending on the severity of the problem.

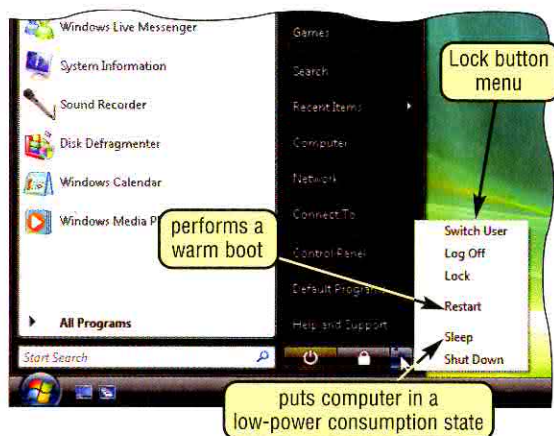


FIGURE 8-2 To reboot a running computer, click Restart on the Lock button menu.

Step 5: If the POST completes successfully, the BIOS searches for specific operating system files called *system files*. The BIOS may look first to see if a USB flash drive plugged in a USB port or a disc in a CD or DVD drive contains the system files. If these ports or drives do not contain media or if the system files are not on media in the port or drive, the BIOS looks in drive C (the designation usually given to the first hard disk) for the system files.

Step 6: Once located, the system files load into memory (RAM) from storage (usually the hard disk) and execute. Next, the kernel of the operating system loads into memory. Then, the operating system in memory takes control of the computer.

Step 7: The operating system loads system configuration information. In Windows Vista, the *registry* consists of several files that contain

the system configuration information. Windows Vista constantly accesses the registry during the computer's operation for information such as installed hardware and software devices and individual user preferences for mouse speed, passwords, and other information. In addition, the Windows Vista registry constantly checks credentials of users to verify they have the necessary privileges to run programs.

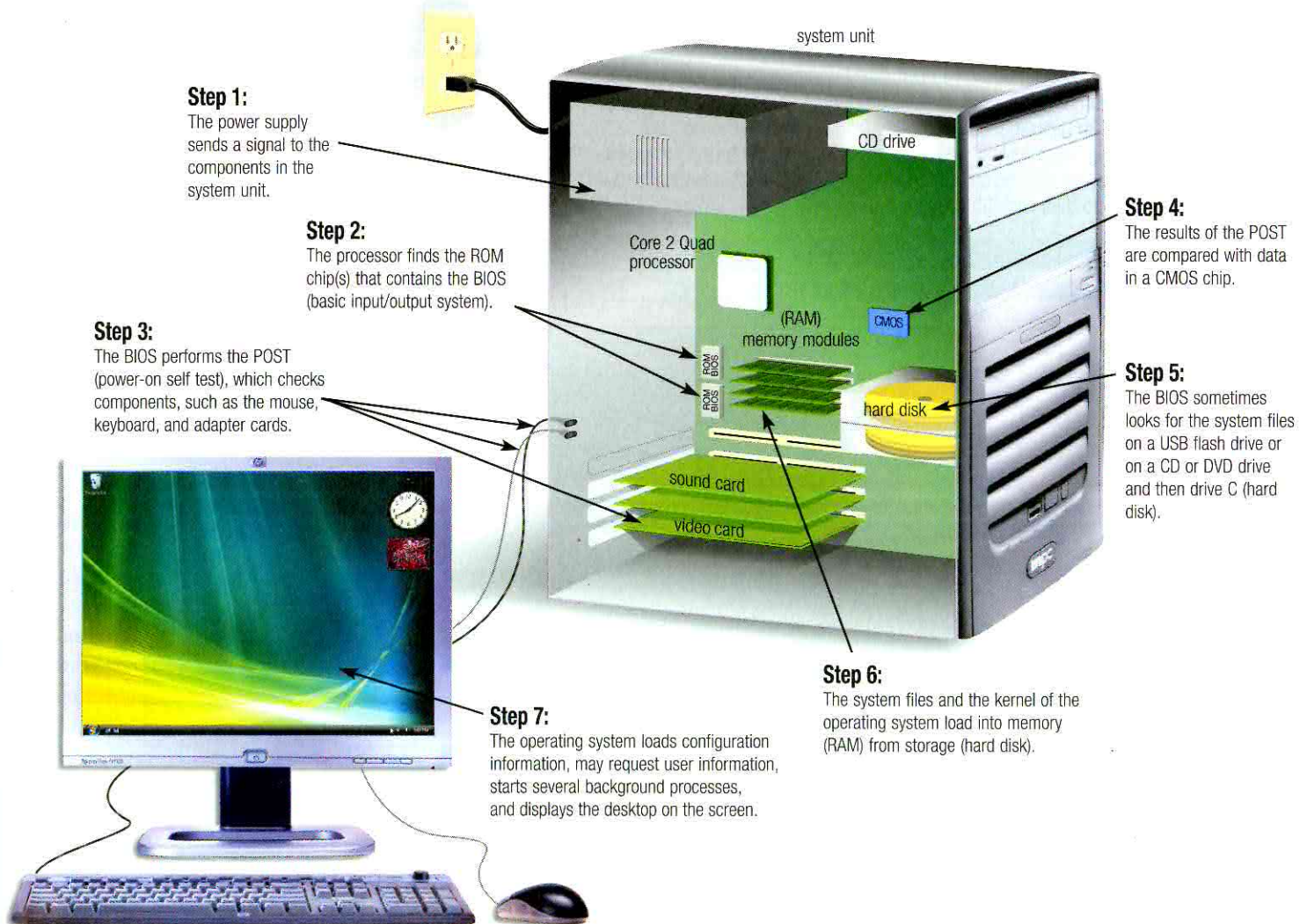
Necessary operating system files are loaded into memory. On some computers, the operating system verifies that the person attempting to use the computer is a legitimate user. Finally, the Windows Vista desktop and icons are displayed on the screen. The operating system executes programs in the *Startup folder*, which contains a list of programs that open automatically when you boot the computer.

WEB LINK 8-1

Windows Registry

For more information, visit scs.site.com/dc2009/ch8/weblink and then click Windows Registry.

FIGURE 8-3 HOW A PC BOOTS



BOOT DISK A boot drive is the drive from which your personal computer boots (starts). In most cases, drive C (the hard disk) is the boot drive. Sometimes a hard disk becomes damaged and the computer cannot boot from the hard disk. In this case, you can boot from a special disk, called a **boot disk** or a **recovery disk**, that contains a few system files that will start the computer. When you purchase a computer, it usually includes a boot disk in the form of a CD. If you do not have a boot disk, the operating system may provide a means to create one. The Windows Vista installation disc is itself a boot disk, which you can use to start Windows Vista in the event you cannot boot from the hard disk.

FAQ 8-1

How do I shut down a computer that uses Windows Vista?

The Start menu in Windows Vista provides many options from which to choose when you are finished using your computer. By default, clicking the Power button on the Start menu will place your computer in *sleep mode*, which is a low-power state that allows you quickly to resume work when you return to your computer. You are able to configure the default behavior of the Power button. If you click the arrow next to the Lock button, you can select commands that allow you to switch users, log off, lock the computer, restart the computer, put the computer to sleep, put the computer in hibernate mode (allows you to power off the computer, and then resume from where you left off when you turn it on again), and shut down (power off) the computer. For more information, visit scs.site.com/dc2009/ch8/faq and then click Shut Down Options.

Providing a User Interface

You interact with software through its user interface. That is, a **user interface** controls how you enter data and instructions and how information is displayed on the screen. Two types of user interfaces are command-line and graphical. Operating systems often use a combination of these interfaces to define how a user interacts with a computer.

COMMAND-LINE INTERFACE To configure devices, manage system resources, and troubleshoot network connections, network administrators and other advanced users work with a command-line interface. In a *command-line interface*, a user types commands or presses special keys on the keyboard (such as function keys or key combinations) to enter data and instructions (Figure 8-4). Command-line interfaces often are difficult to use because they require exact spelling, grammar, and punctuation. Minor errors, such as a missing period, generate an error message. Command-line interfaces, however, give a user more control to manage detailed settings. When working with a command-line interface, the set of commands entered into the computer is called the *command language*.

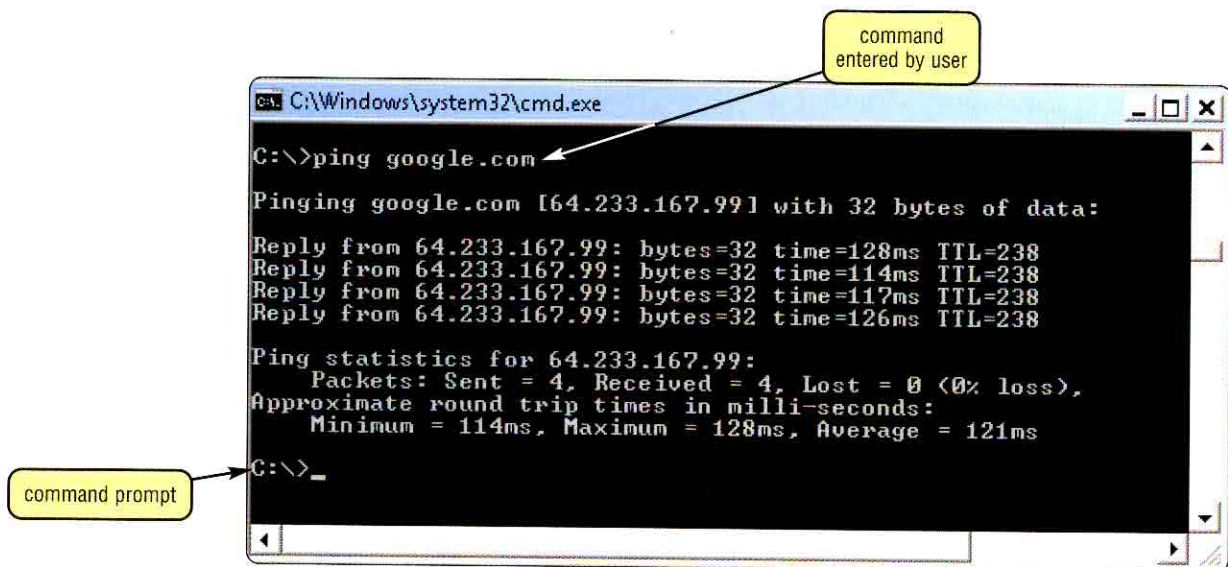


FIGURE 8-4 A command-line interface is difficult to use because it requires you enter exact spelling, grammar, and punctuation.

GRAPHICAL USER INTERFACE

Most users today work with a graphical user interface. With a *graphical user interface (GUI)*, you interact with menus and visual images such as buttons and other graphical objects to issue commands. Many current GUI operating systems incorporate features similar to those of a Web browser, such as links and navigation buttons (i.e., Back button and Forward button). Windows Vista offers two different GUIs, depending on your hardware configuration. Computers with less than 1 GB of RAM work with the *Windows Vista Basic interface* (Figure 8-5a). Computers with more than 1 GB of RAM work with the *Windows Vista Aero interface*, known as *Windows Aero* (Figure 8-5b), which provides an enhanced visual look, additional navigation options, and animation.

Managing Programs

Some operating systems support a single user and only one running program at a time. Others support thousands of users running multiple programs. How an operating system handles programs directly affects your productivity.

A *single user/single tasking* operating system allows only one user to run one program at a time. For example, if you are working in a graphics program and want to check e-mail messages, you must quit the graphics program before you can run the e-mail program. Early systems were single user/single tasking. Smart phones and other personal mobile devices, however, often use a single user/single tasking operating system. Most other operating systems today are multitasking.

A *single user/multitasking* operating system allows a single user to work on two or more programs that reside in memory at the same time. Using the example

FIGURE 8-5a (Windows Vista Basic interface)

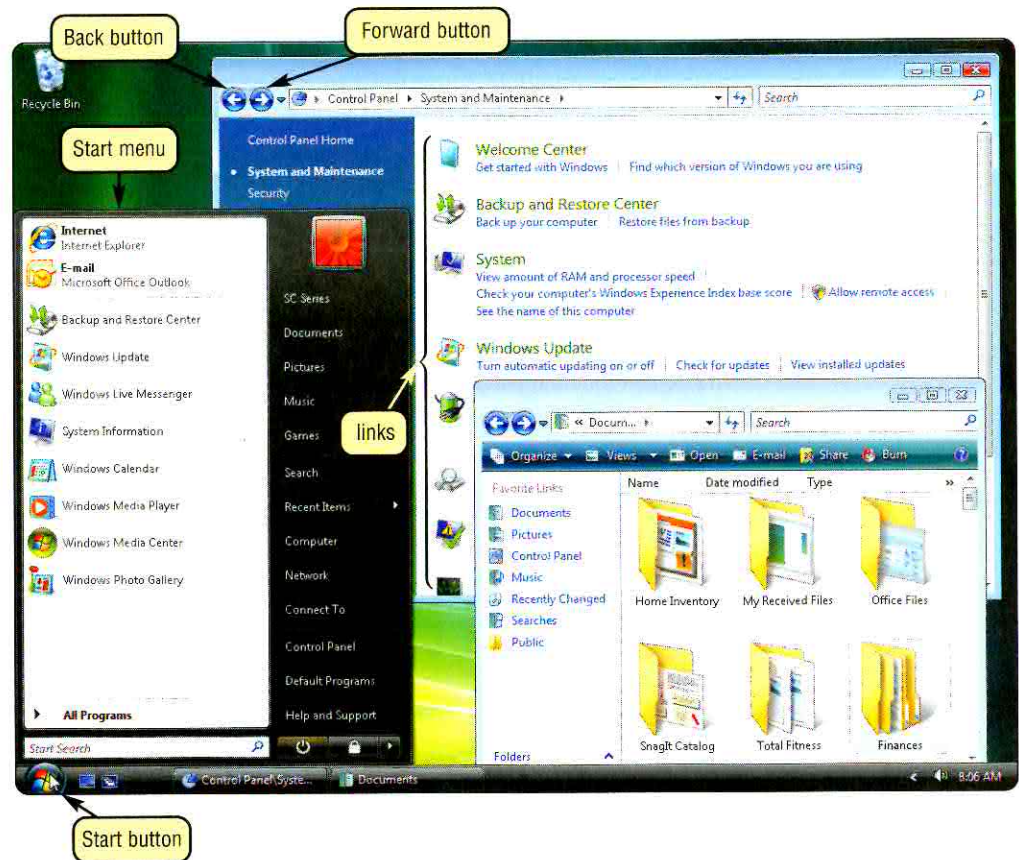


FIGURE 8-5b (Windows Aero interface)

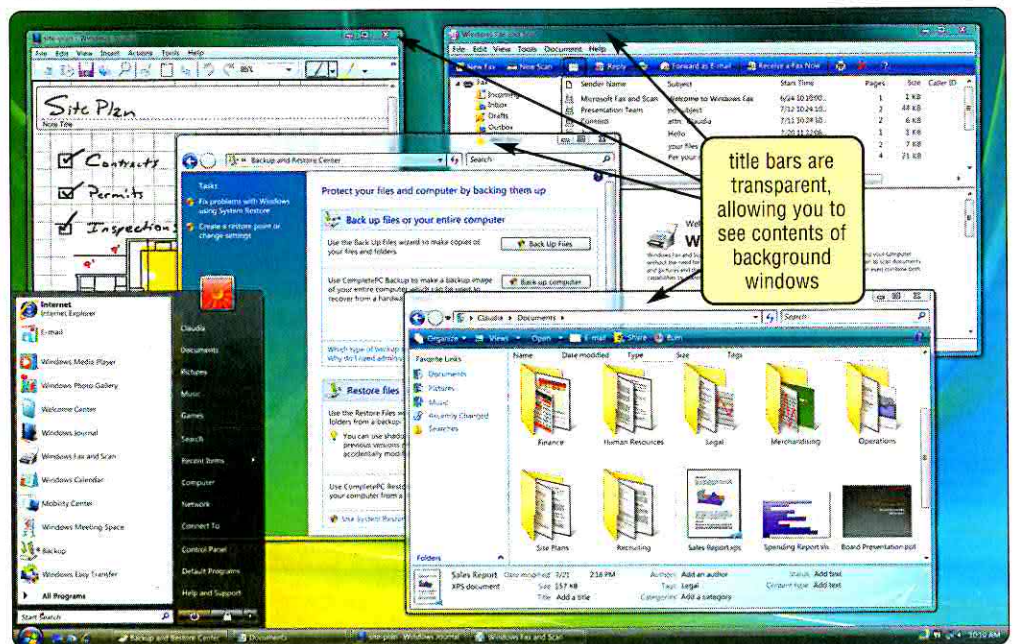


FIGURE 8-5 Windows Vista offers two different graphical user interfaces, depending on your hardware configuration.

just cited, if you are working with a single user/multitasking operating system, you do not have to quit the graphics program to run the e-mail program. Both programs can run concurrently. Users today typically run multiple programs concurrently. It is common to have an e-mail program and Web browser open at all times, while working with application programs such as word processing or graphics.

When a computer is running multiple programs concurrently, one program is in the foreground and the others are in the background. The one in the foreground is the active program, that is, the one you currently are using. The other programs

running but not in use are in the *background*. In Figure 8-6, the Microsoft PowerPoint program, which is showing a slide show, is in the foreground, and three other programs are running in the background (Microsoft Excel, Windows Media Player, and Chess Titans). For example, Windows Media Player can be playing music while you are modifying the slide show.

The foreground program typically displays on the desktop, and the background programs are hidden partially or completely behind the foreground program. You easily can switch between foreground and background programs. To make a program active (in the foreground) in

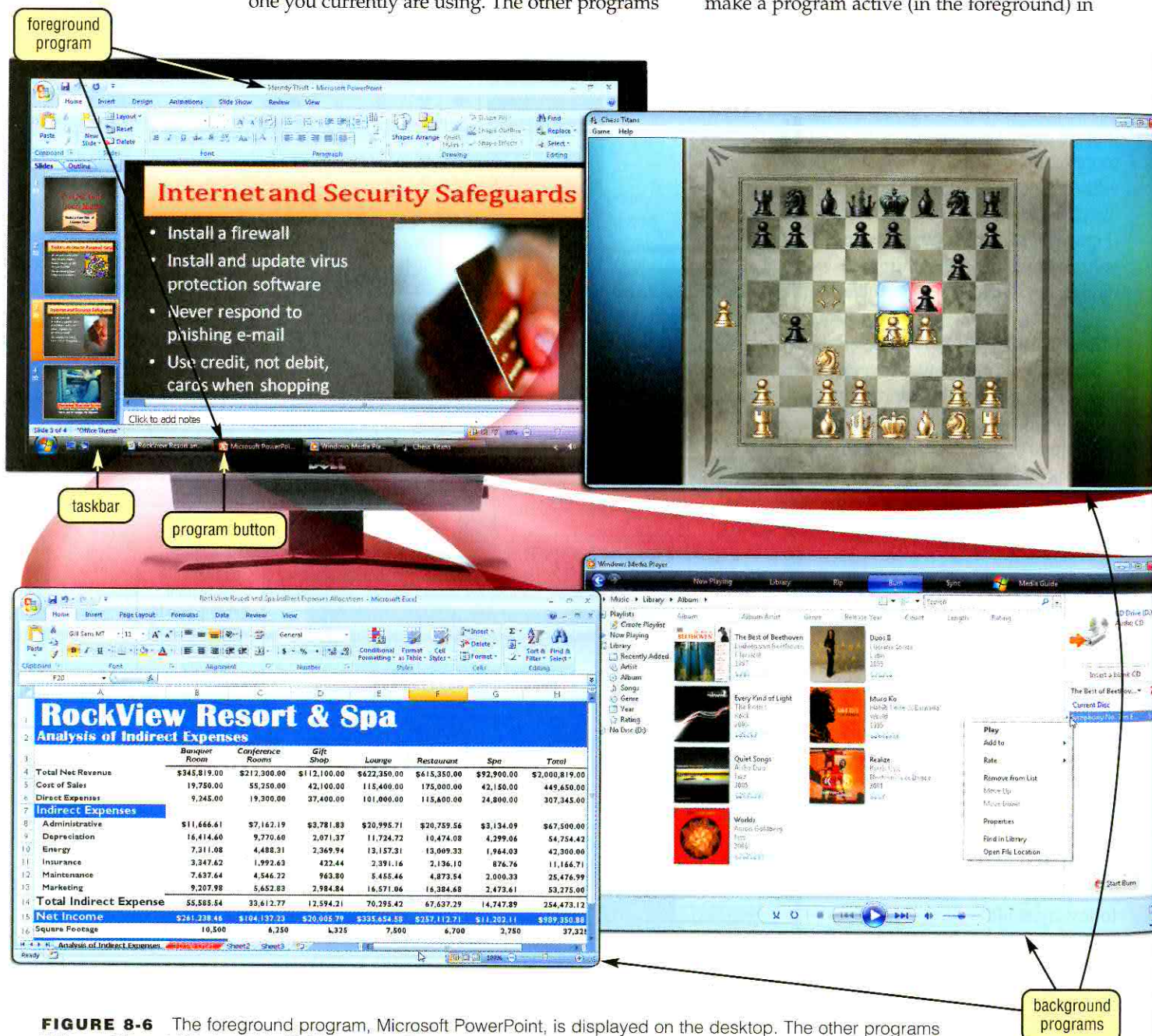


FIGURE 8-6 The foreground program, Microsoft PowerPoint, is displayed on the desktop. The other programs (Microsoft Excel, Windows Media Player, and Chess Titans) are in the background.

Windows Vista, click its program button on the taskbar. This causes the operating system to place all other programs in the background.

In addition to application programs, an operating system manages other processes. These processes include utilities or routines that provide support to other programs or hardware. Some are memory resident. Others run as they are required. Figure 8-7 shows a list of some processes running on a Windows Vista computer. The list contains the applications programs running, as well as other programs and processes.

Some operating systems use preemptive multitasking to prevent any one process from monopolizing the computer's resources. With *preemptive multitasking*, the operating system interrupts a program that is executing and passes control to another program waiting to be executed. An advantage of preemptive multitasking is the operating system regains control if one program stops operating properly.

A *multiuser* operating system enables two or more users to run programs simultaneously. Networks, servers, mainframes, and supercomputers allow hundreds to thousands of users to connect at the same time, and thus are multiuser.

A *multiprocessing* operating system supports two or more processors running programs at the same time. Multiprocessing involves the coordinated processing of programs by more than one processor. Multiprocessing increases a computer's processing speed.

A computer with separate processors also can serve as a fault-tolerant computer. A *fault-tolerant computer* continues to operate when one of its components fails, ensuring that no data is lost. Fault-tolerant computers have duplicate components such as processors, memory, and disk drives. If any one of these components fails, the computer switches to the duplicate component and continues to operate. Airline reservation systems, communications networks, automated teller machines, and other systems that must be operational at all times use fault-tolerant computers.

Managing Memory

The purpose of **memory management** is to optimize the use of random access memory (RAM). As Chapter 4 discussed, RAM consists of one or more chips on the motherboard that

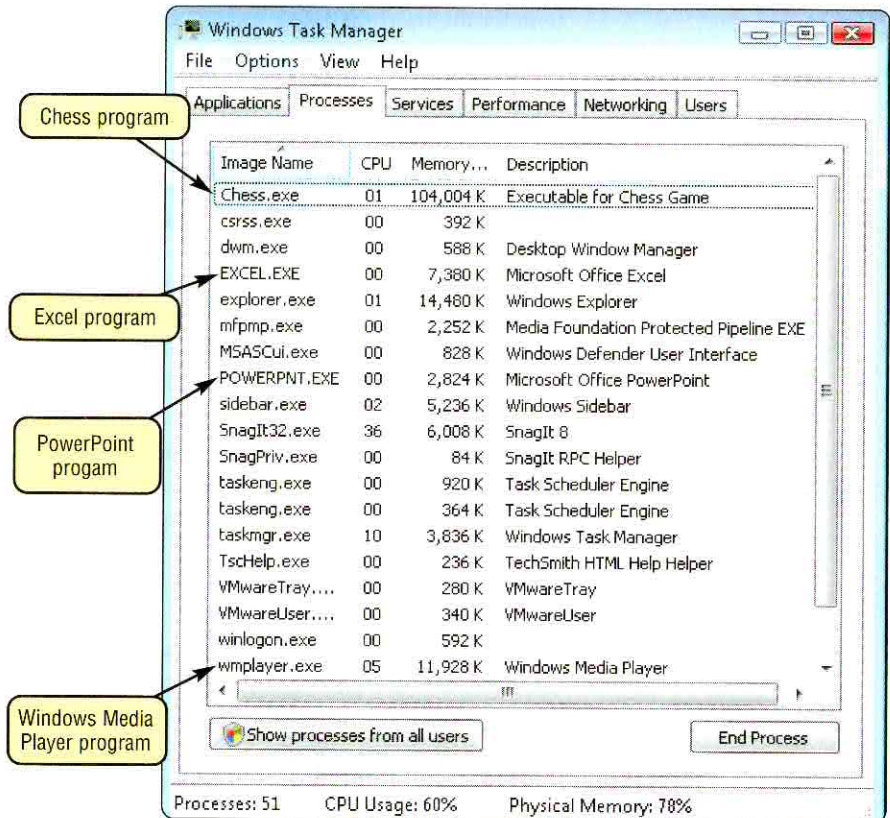


FIGURE 8-7 An operating system manages multiple programs and processes while you use the computer.

hold items such as data and instructions while the processor interprets and executes them. The operating system allocates, or assigns, data and instructions to an area of memory while they are being processed. Then, it carefully monitors the contents of memory. Finally, the operating system releases these items from being monitored in memory when the processor no longer requires them.

If you have multiple programs running simultaneously, it is possible to run out of RAM. For example, assume an operating system requires 512 MB of RAM, an antivirus program — 256 MB of RAM, a Web browser — 128 MB of RAM, a business software suite — 512 MB of RAM, and a photo editing program — 256 MB of RAM. With all these programs running simultaneously, the total RAM required would be 1664 MB of RAM ($512 + 256 + 128 + 512 + 256$). If the computer has only 512 MB of RAM, the operating system may have to use virtual memory to solve the problem.

With **virtual memory**, the operating system allocates a portion of a storage medium,

usually the hard disk, to function as additional RAM (Figure 8-8). As you interact with a program, part of it may be in physical RAM, while the rest of the program is on the hard disk as virtual memory. Because virtual memory is slower than RAM, users may notice the computer slowing down while it uses virtual memory.

The area of the hard disk used for virtual memory is called a *swap file* because it swaps (exchanges) data, information, and instructions between memory and storage. A *page* is the amount of data and program instructions that can swap at a given time. The technique of swapping items between memory and storage, called *paging*, is a time-consuming process for the computer.

When an operating system spends much of its time paging, instead of executing application software, it is said to be *thrashing*. If application software, such as a Web browser, has stopped responding and the hard disk's LED blinks repeatedly, the operating system probably is thrashing.

Instead of using a hard disk as virtual memory, Windows Vista users can increase the size

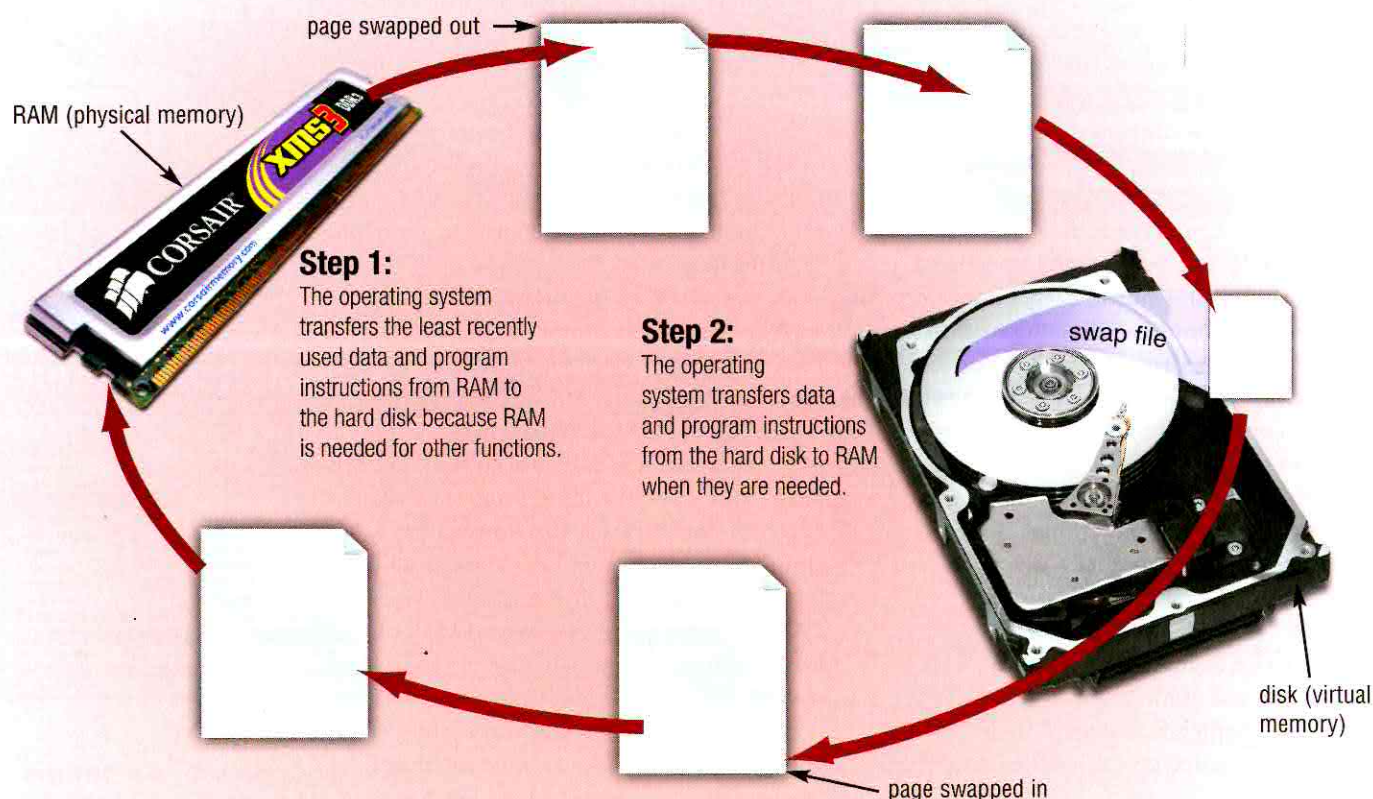
of memory through Windows ReadyBoost, which can allocate up to 4 GB of removable flash memory devices as additional memory cache. Users notice better performance with Windows ReadyBoost versus hard disk virtual memory because the operating system accesses a flash memory device, such as a USB flash drive or SD memory card, more quickly than it accesses a hard disk.

FAQ 8-2

How can I stop a computer from thrashing?

Try to quit the program that stopped responding. If the computer does not respond and continues to thrash, do a warm boot. When the computer reboots, check whether the available hard disk space is less than 200 MB. If it is, remove unnecessary files from the hard disk and if possible uninstall seldom used programs. Defragment the hard disk (discussed later in this chapter). If thrashing continues to occur, you may need to install more RAM in the computer. For more information, visit scsite.com/dc2009/ch8/faq and then click Optimizing Memory.

FIGURE 8-8 HOW A COMPUTER MIGHT USE VIRTUAL MEMORY



Coordinating Tasks

The operating system determines the order in which tasks are processed. A task, or job, is an operation the processor manages. Tasks include receiving data from an input device, processing instructions, sending information to an output device, and transferring items from storage to memory and from memory to storage.

A multituser operating system does not always process tasks on a first-come, first-served basis. Sometimes, one user may have a higher priority than other users. In this case, the operating system adjusts the schedule of tasks.

Sometimes, a device already may be busy processing one task when it receives a second task. This occurs because the processor operates at a much faster rate of speed than peripheral devices. For example, if the processor sends five documents to a printer, the printer can print only one document at a time and store as many documents as its memory can handle.

While waiting for devices to become idle, the operating system places items in buffers. A **buffer** is a segment of memory or storage in which items are placed while waiting to be transferred from an input device or to an output device.

The operating system commonly uses buffers with printed documents. This process, called **spooling**, sends documents to be printed to a buffer instead of sending them immediately to the printer. The buffer holds the documents waiting to print while the printer prints from the buffer at its own rate of speed. By spooling documents to a buffer, the processor can continue interpreting and executing instructions

while the printer prints. This allows users to work on the computer for other activities while a printer is printing. Multiple documents line up in a **queue** (pronounced Q) in the buffer. A program, called a *print spooler*, intercepts documents to be printed from the operating system and places them in the queue (Figure 8-9).

Configuring Devices

A **driver**, short for *device driver*, is a small program that tells the operating system how to communicate with a specific device. Each device on a computer, such as the mouse, keyboard, monitor, printer, card reader/writer, and scanner, has its own specialized set of commands and thus requires its own specific driver. When you boot a computer, the operating system loads each device's driver. These devices will not function without their correct drivers.

If you attach a new device to a computer, such as a printer or scanner, its driver must be installed before you can use the device. Today, many devices and operating systems support Plug and Play. As discussed in Chapter 4, **Plug and Play** means the operating system automatically configures new devices as you install them. Specifically, it assists you in the device's installation by loading the necessary drivers automatically and checking for conflicts with other devices. With Plug and Play, a user plugs in a device, turns on the computer, and then uses the device without having to configure the system manually. Devices that connect to a USB port on the system unit typically are Plug and Play.

WEB LINK 8-2

Plug and Play

For more information, visit scs.site.com/dc2009/ch8/weblink and then click **Plug and Play**.

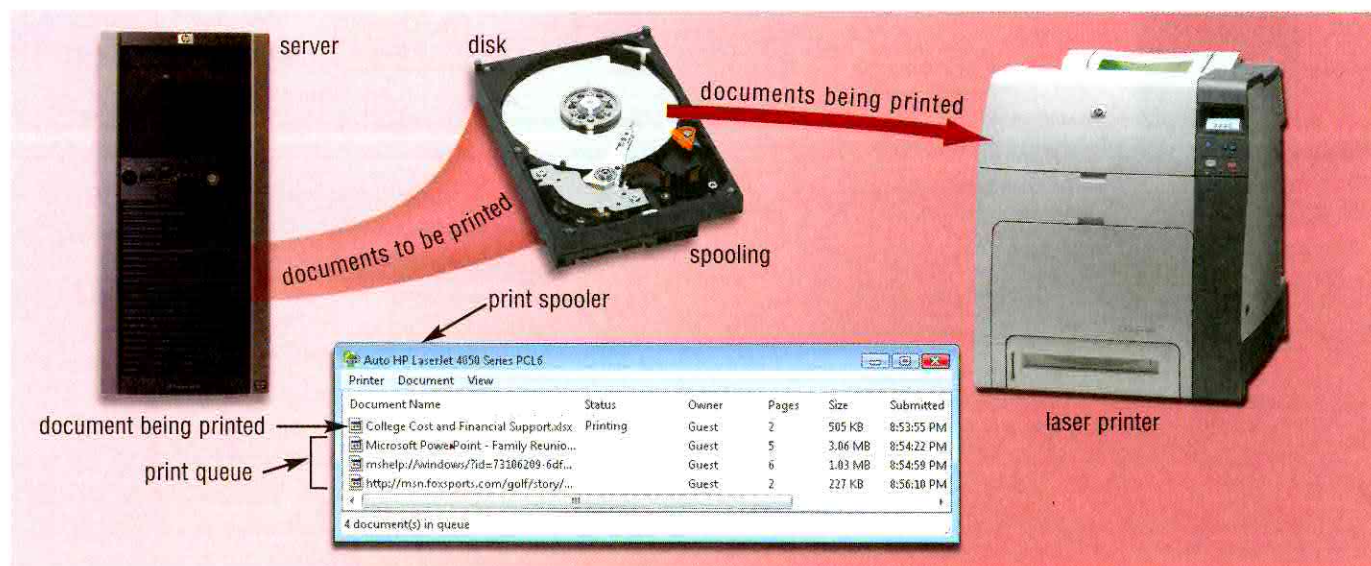


FIGURE 8-9 Spooling increases both processor and printer efficiency by placing documents to be printed in a buffer on disk before they are printed. This figure illustrates three documents in the queue with one document printing.

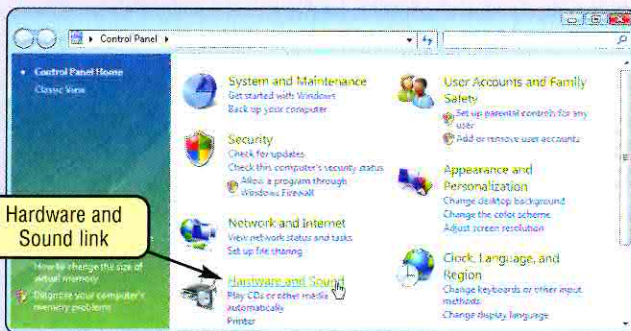
If you have a device that is not Plug and Play, you can install the driver manually. Figure 8-10 shows how Windows Vista installs a driver for an unrecognized scanner or camera. For many devices, the operating system includes the necessary drivers. Windows Vista, for

example, automatically updates drivers on your computer regularly. If, however, the required drivers are not on your computer, you can install them from the CD provided with the purchased device.

FIGURE 8-10 HOW TO USE WINDOWS VISTA TO INSTALL DRIVERS FOR AN UNRECOGNIZED SCANNER OR CAMERA

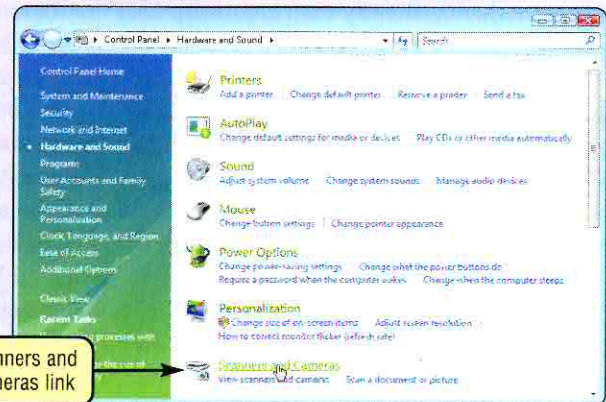
Step 1:

Open the Control Panel window. Point to the Hardware and Sound link.



Step 2:

Click the Hardware and Sound link to display the Hardware and Sound options. Point to the Scanners and Cameras link.



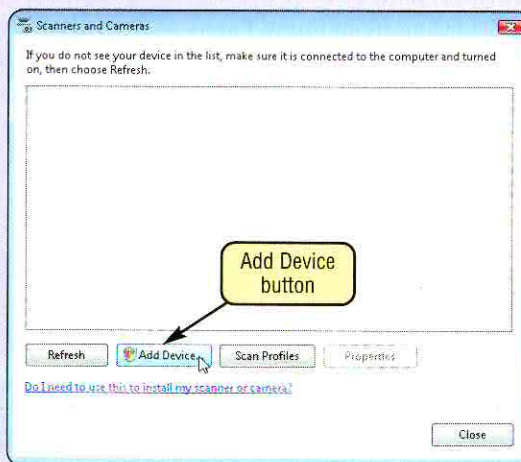
Step 4:

Click the Add Device button to start the Scanner and Camera Installation Wizard. Point to the Next button.



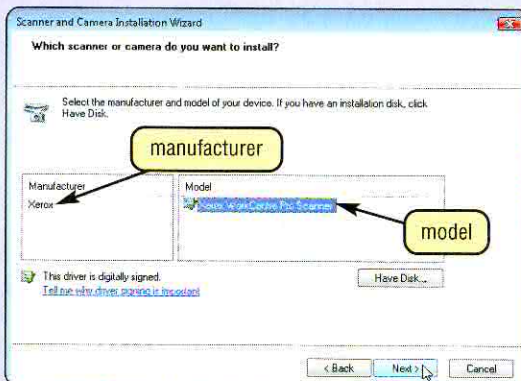
Step 3:

Click the Scanners and Cameras link to display the Scanners and Cameras dialog box. Point to the Add Device button.



Step 5:

Click the Next button to proceed with the wizard. Select the correct manufacturer and model of scanner or camera. Follow the on-screen instructions to complete installation of the necessary driver files for the selected device.



FAQ 8-3

What happens when I install a new device on my computer?

When you install a new device on your computer, Windows Vista searches its database of common drivers that can be used to communicate with the new device. If Windows cannot locate a driver for the device, and if you have an Internet connection, Windows will search an online repository of device drivers. If Windows still is unable to find a driver, you can download one from the manufacturer's Web site. For more information, visit scs.site.com/dc2009/ch8/faq and then click Drivers.

Establishing an Internet Connection

Operating systems typically provide a means to establish Internet connections. For example, Windows Vista automatically configures some broadband Internet connections as soon as you connect to the broadband line. Otherwise, Windows Vista includes a 'Connect to a network' wizard that guides users through the process of setting up a connection between a computer and an Internet access provider (Figure 8-11).

Some operating systems also include a Web browser and an e-mail program, enabling you to begin using the Web and communicate with others as soon as you set up the Internet connection. Some also include utilities to protect computers from unauthorized intrusions and unwanted software such as viruses and spyware. Read Ethics & Issues 8-1 for a related discussion.

Monitoring Performance

Operating systems typically contain a performance monitor. A **performance monitor** is a program that assesses and reports information about various computer resources and devices (Figure 8-12). For example, users can monitor the processor, disks, network, and memory usage.

The information in performance reports helps users and administrators identify a problem with resources so that they can try to resolve any problems. If a computer is running very slow, for example, the performance monitor may determine that the computer's memory is being used to its maximum. Thus, you might consider installing additional memory in the computer.

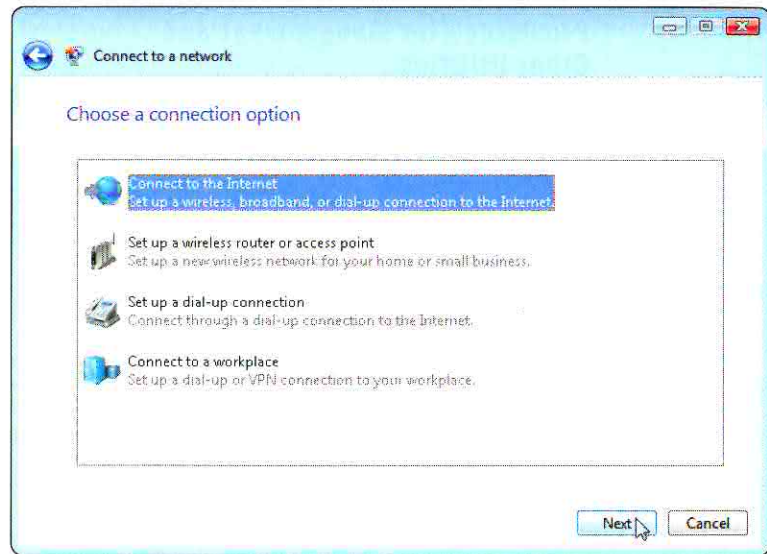


FIGURE 8-11 To connect to a network using Windows Vista, click the Start button, click Connect To, and then click 'Set up a connection or network'.

ETHICS & ISSUES 8-1

What Should Be in an Operating System?

Microsoft includes a Web browser, movie making software, a word processing program, plug-ins, a personal firewall, spyware remover, and other programs, utilities, and features with its Windows operating systems. Apple bundles QuickTime, CD burning software, and other programs, utilities, and features into Mac OS X. Manufacturers say that combining additional features and programs with their operating systems is a convenience for consumers and sometimes integral to the operating systems' performance. Microsoft's bundling of its Web browser with its Windows operating system was the proximate cause of an antitrust action against the software giant. Microsoft no longer includes its media player and other software in its Windows Vista operating system that it sells in the European Union and other countries as a result of antitrust action. Critics also insist that bundling programs with an operating system forces consumers to pay for programs that may be inferior to those available elsewhere. Is bundling programs with an operating system fair, or is it a monopolistic practice? Why? Who should decide what an operating system should include? Why? Is bundling programs with an operating system good or bad for consumers? Why or why not?

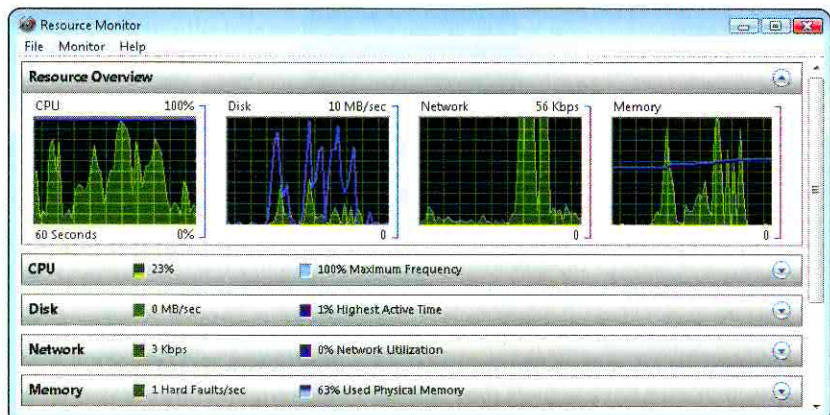


FIGURE 8-12 The Windows Vista Resource Monitor above is tracking CPU (processor), disk, network, and memory usage.

Providing File Management and Other Utilities

Operating systems often provide users with the capability of managing files, searching for files, viewing images, securing a computer from unauthorized access, uninstalling programs, scanning disks, defragmenting disks, diagnosing problems, backing up files and disks, and setting up screen savers. A later section in the chapter discusses these utilities in depth.

Controlling a Network

Some operating systems are network operating systems. A **network operating system**, or *network OS*, is an operating system that organizes and coordinates how multiple users access and share resources on a network. Resources include hardware, software, data, and information. For example, a network OS allows multiple users to share a printer, Internet access, files, and programs.

Some operating systems have network features built into them. In other cases, the network OS is a set of programs separate from the operating system on the client computers that access the network. When not connected to the network, the client computers use their own operating system. When connected to the network, the network OS may assume some of the operating system functions.

The *network administrator*, the person overseeing network operations, uses the network OS to add and remove users, computers, and other devices to and from the network. The network administrator also uses the network operating system to install software and administer network security.

Administering Security

The network administrator uses the network OS to establish permissions to resources. These permissions define who can access certain resources and when they can access those resources.

For each user, the network administrator establishes a user account, which enables a user to access, or **log on** to, a computer or a network. Each user account typically consists of a user name and password (Figure 8-13). A **user name**, or **user ID**, is a unique combination of characters, such as letters of the alphabet or numbers, that identifies one specific user. Many users select a combination of their first and last names as their user name. A user named Henry Baker might choose H Baker as his user name.

A **password** is a private combination of characters associated with the user name that

allows access to certain computer resources. Some operating systems allow the network administrator to assign passwords to files and commands, restricting access to only authorized users.

To prevent unauthorized users from accessing computer resources, keep your password confidential. While entering your password, most computers hide the actual password characters by displaying some other characters, such as asterisks (*) or dots. After entering a user name and password, the operating system compares the user's entry with a list of authorized user names and passwords. If the entry matches the user name and password kept on file, the operating system grants the user access. If the entry does not match, the operating system denies access to the user.

The operating system records successful and unsuccessful logon attempts in a file. This allows the network administrator to review who is using or attempting to use the computer. Network administrators also use these files to monitor computer usage.

To protect sensitive data and information further as it travels over the network, a network operating system may encrypt it. *Encryption* is the process of encoding data and information into an unreadable form. Network administrators can set up a network to encrypt data as it travels over the network to prevent unauthorized users from reading the data. When an authorized user attempts to read the data, it automatically is decrypted, or converted back into a readable form. Read Ethics & Issues 8-2 for a related discussion.



FIGURE 8-13 Most multiuser operating systems allow each user to log on, which is the process of entering a user name and a password into the computer.